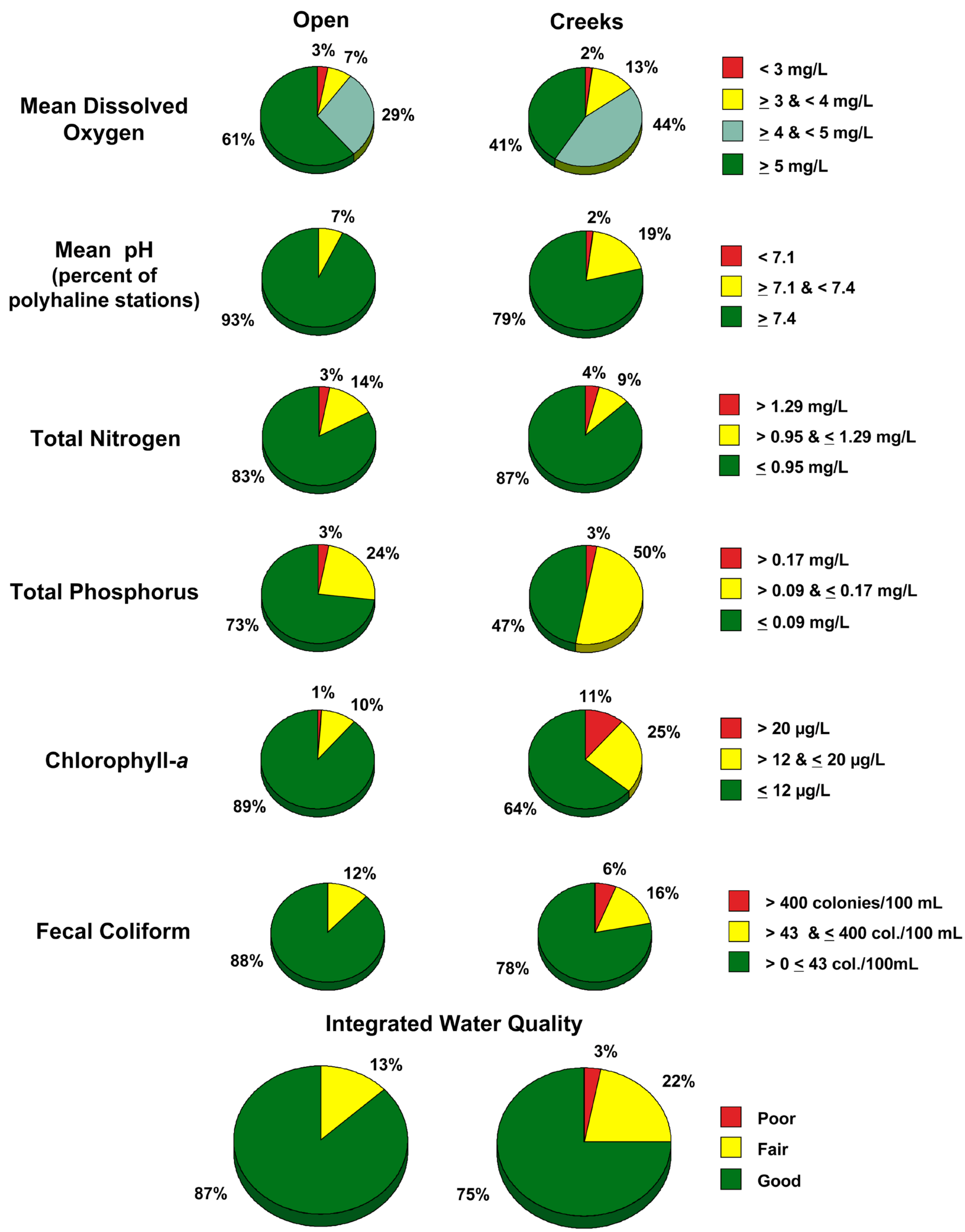

Figure 3.2.2. Comparison of the percent of the state's coastal habitat that represented various water quality conditions for selected water quality parameters and for the integrated water quality index.

averages were > 4.0 mg/L. Approximately 2% of the state's tidal creek habitat had average DO levels < 3.0 mg/L and 13% of this habitat had DO levels between 3.0 and 4.0 mg/L, which is similar to the previous survey period (Van Dolah *et al.*, 2004a) Tidal creek sites often had a greater range in DO concentrations than the open water sites (data online).

Although numeric state DO standards apply to all waters, the SCECAP data continue to suggest that lower DO concentrations in tidal creeks may be normal during the summer months compared to larger water bodies. When making regulatory decisions in such situations, the practice of considering natural background conditions seems appropriate. Even so, creek sites with mean DO levels < 3.0 mg/L may not fully support biological assemblages, especially during periods when DO levels are less than 2.0 mg/L (hypoxic conditions). Hypoxic conditions are known to be limiting to many estuarine and marine biota (Gibson *et al*., 2000).

As noted in the previous two survey periods (Van Dolah *et al*., 2002a, 2004a), the instantaneous measures of bottom DO were, on average, lower than the mean DO values obtained from the 25-hr deployment of water quality datasondes among both the open water (0.7 mg/L difference) and tidal creek sites (1.1 mg/L difference, data online). In contrast to the previous surveys, these differences were statistically significant ($p < 0.002$) during the current survey. The instantaneous bottom DO measure at each site was only weakly correlated to the average bottom DO obtained from the 25-hr instrument deployment ($r^2 = 0.22$), which was also the case in the previous surveys. While instantaneous measures of DO and other water quality parameters are the only feasible approach for SCDHEC to use for the year-round assessment of coastal water quality, mean DO conditions are best measured over a longer period that includes both day and night measures during all tidal stages.

Finally, it should be noted that SCDHEC uses surface water quality measures for regulatory and reporting purposes. The mean differences between surface and bottom readings during the primary site visit was only 0.2 mg/L for both habitat types and only two open water sites had a difference in DO readings of more than 1.0 mg/L (data online). Thus, the surface readings should be reasonably protective of bottom water habitats for South Carolina waters.

pH

Measures of pH provide another indicator of water quality in estuarine habitats that has often been ignored by other sampling programs at the state or national level. Measures of pH are based on a logarithmic scale, so even small changes in the value can result in significant stress to estuarine organisms (Bamber, 1987, 1990; Ringwood and Keppler, 2002). Unusually low or high pH values may indicate the presence of pollutants (e.g. release of acids or caustic materials) or high concentrations of carbon dioxide (Gibson *et al.*, 2000). Because salinity and alkalinity affect the pH of estuarine waters, SCDHEC has established water quality standards that account for these effects. The pH in Class SA and SB tidal saltwater areas should not vary more than one-half of a pH unit above or below effluent-free waters in the same geologic area having a similar salinity, alkalinity and temperature, and values should never be lower than 6.5 or higher than 8.5. Shellfish Harvesting waters (SFH) shouldn't deviate more than 0.3 units from effluent-free waters. Based on these criteria, pH criteria were established for SCECAP assessments using data collected from pristine environments sampled in 1999-2000 (e.g. Cape Romain National Wildlife Refuge, ACE Basin and North Inlet-Winyah National Estuarine Research Reserves, SFH class saltwaters) to identify pH levels that were considered to represent good, fair, and poor conditions for polyhaline waters (> 18 ppt; Van Dolah *et al*., 2002a). For polyhaline waters, pH levels ≥ 7.4 are considered to be good. Values below 7.4 and above 7.1 pH units are considered to be fair since they represent the lower 10^{th} percentile of all pH records observed for polyhaline waters during the 1999-2000 survey. Values below 7.1 pH units are below the 0.5 pH unit variation allowed for effluent-free waters and are considered to be poor pH conditions. Criteria are still not established for lower salinity waters since the extreme drought conditions experienced from 1999-2002 limited the number of sites with salinities < 18 ppt. The return of normal rainfall conditions should allow us to develop criteria for oligohaline and mesohaline waters following the 2005-2006 survey now in progress.

The overall average pH observed in 2003-2004 based on the 25-hr measures was 7.3 in tidal creek habitats and 7.6 in polyhaline open water habitats, with approximately 79% of the state's polyhaline tidal creek habitat and 93% of the open water habitat having good pH conditions (Figure 3.2.2, data online). Criteria for lower salinity waters are still not available using the approach developed by SCECAP. As with the previous surveys, the mean instantaneous pH of surface waters within each habitat was within 0.1 pH unit of the mean bottom pH based on the continuous measurements. All mean values were also very similar to the averages observed in the 1999-2000 and 2001-2002 surveys (Van Dolah *et al*., 2002a, 2004a). Mean pH values were significantly lower in the tidal creek habitats compared to the open water habitats ($p < 0.001$) with a higher percentage of the state's polyhaline creek habitat having pH values considered to be only fair or poor compared to polyhaline open water habitat (Figure 3.2.2). Similar trends were noted in the previous two surveys (Van Dolah *et al*., 2002a, 2004a). Additionally, five tidal creek stations (RT032031, RT032046, RT032052, RT042062, RT042084) and two open water stations (RO036049, RO036054) had 25-hr pH means below the minimum (6.5) criteria established by SCDHEC. The locations of sites that had moderately low to very low pH values are provided in Appendix 2.

Nutrients

Nutrient concentrations in estuarine waters can become high due to runoff from upland urban and suburban developments, agricultural fields adjacent to estuarine habitats, riverine input of nutrient-rich waters from inland areas, and atmospheric deposition. High nutrient levels can lead to eutrophication of estuarine waters resulting in excessive algal blooms (including harmful algal species), decreased dissolved oxygen, and other undesirable effects that adversely affect estuarine biota (Bricker *et al*., 1999). Currently, there are no state standards in South Carolina estuarine waters for the various forms of nitrogen (except ammonia) and phosphorus. Therefore, the SCECAP data are compared to SCDHEC's historical database (SCDHEC, 1998a) to identify waters showing evidence of elevated nutrients. Values below the 75th percentile of the historical database are considered to be good, values above the 75th percentile and below the 90th percentile are considered to be moderately elevated (fair), and values above the 90th percentile are considered to be high (poor).

Nitrogen:

Total nitrogen (TN), as measured by the SCDHEC laboratory, is best represented by the sum of nitrate-nitrite and total Kjeldahl nitrogen (TKN). Based on historical SCDHEC (1998a) data, TN values ≤ 0.95 mg/L are considered to be good. Values > 0.95 mg/L and < 1.29 mg/L are considered to be fair since they are above the upper 75th percentile of the historical records and below the 90th percentile of those records. Values above 1.29 mg/L are considered to be poor since they represent the upper 90th percentile of the historical records.

In 2003-2004, the mean concentration of TN was 0.67 mg/L among the tidal creek sites and 0.66 mg/L among the open water sites. There was no significant difference between mean TN values observed in the tidal creek versus open water habitat ($p = 0.596$), which was also the case in the 2001-2002 survey, but not in the 1999-2000 survey when tidal creeks had a significantly higher nitrogen concentration compared to open water habitat. Approximately 93% of the nitrogen was in the form of TKN (organic fraction plus ammonia) when all stations were considered collectively. Mean nitrate-nitrite values in the creeks and open water sites were only 0.03 and 0.05 mg/L, respectively, which was similar to the values observed in the previous surveys.

Using the sum of the detectable values for nitrate-nitrite and TKN as an indication of TN enrichment, about 83% of open water habitat and 87% of tidal creek habitat had nitrogen levels indicative of good conditions. Fourteen percent of the state's open water habitat and 9% of the state's creek habitat had moderately elevated TN concentrations, considered to be fair (Figure 3.2.2, data online). Additionally, 3% of the open water habitat and 4% of the creek habitat had nutrient values considered to be poor. The percentage of the state's estuarine habitat with fair or poor TN concentrations was higher than observed in either the 1999-2000 or 2001-2002 surveys (Figure 3.2.3). This probably reflects the effects of increased runoff from upland habitat as compared to the drought period of the previous two surveys. Sites with very high TN concentrations were located in a creek in Clark Sound